Sveriges lantbruksuniversitet
Fakulteten för veterinärmedicin och husdjursvetenskap

Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science

Cow behaviour in AMS

Comparison of two different systems

Yazdan Shahhosseini

Examensarbete / SLU, Institutionen för husdjurens utfodring och vård, **453**

Uppsala 2013

Degree project / Swedish University of Agricultural Sciences,
Department of Animal Nutrition and Management, **453**

Examensarbete, 30 hp
Masterarbete
Husdjursvetenskap
Degree project, 30 hp
Master Thesis
Animal Science

Sveriges lantbruksuniversitet
Fakulteten för veterinärmedicin och husdjursvetenskap
Institutionen för husdjurens utfodring och vård

Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science
Department of Animal Nutrition and Management

Cow behaviour in AMS

Comparison of two different systems

Yazdan Shahhosseini

Handledare:
Supervisor: Gunnar Pettersson
Ämnesansvarig:
Subject responsibility:
Examinator:
Examiner: Kjell Holtenius
Omfattning:
Extent: 30 hp
Kurstitel:
Course title: Degree project
Kurskod:
Course code: EX0551
Program:
Programme: Animal Science, Master's Programme
Nivå:
Level: Advanced A2E
Utgivningsort:
Place of publication: Uppsala
Utgivningsår:
Year of publication: 2013
Serienamn, delnr: Examensarbete / Sveriges lantbruksuniversitet, Institutionen för husdjurens utfodring och vård, 453
Series name, part No:
On-line publicering: http://epsilon.slu.se
On-line published:
Nyckelord:
Key words: Automatic milking, Cow traffic, Aggression

Content

Abbreviations List:

AM: Automatic Milking

AMS: Automatic Milking System

MS: Milking Station

AW: Waiting Area

FA: Feeding Area

CA: Concentrate Area

DV: Dominance value

Abstract

In this study, two cow traffic systems in automatic milking system (AMS) were observed to evaluate the effects on cow behaviour and also efficiency of barn design. First system (F barn) was Free Cow Traffic where the cows had to pass through the milking station (MS) to enter concentrate area (CA) and the roughage was available in the cubicles' trough. The second system (E barn) was a Forced Cow Traffic with selecting gate and waiting area (WA) and the cows had to pass the selecting gate to enter either WA then MS and finally feeding area (FA) or directly to FA. In this system concentrate troughs were placed in the FA. In each system, behaviours of cows were observed directly for 72 hours. All the interactions between cows in the different areas of the barn were registered and the cubicles conditions (free, occupied and in F barn availability of roughage in the troughs) were registered with 60 minutes intervals. The time spent in CA and WA and dominance value showed a contrary relation ($P<0.055$) while time spent in waiting line (WL) and dominance value had no significant relation.

Introduction

In 1830, Machinery in dairy industry began. The very first milking machine which was operating with entirely mechanical parts, was imitating the hand grip of a milker. The first vacuum operating milking machine was introduced in 1851. From the early 1900s, the milking machines were operating similar to the one nowadays in manual milking machines. The milking machine technology underwent various changes since it was applied in industrial stage. During the 1990s, the technology of robotic milking improved in The Netherlands. In 1998, the first robotic milking unit was installed in Sweden and started to operate. Since then the number of AMS herds increased in a brisk pace. In 2010, the number of AMS herds reached the level of 10 percent of all dairy Swedish herds. In 2009, the number of Swedish dairy farms was 6137, according to the Svensk Mjölk. However, there is a decline in the trend of the number of dairy farms in Sweden. In the past five years, over 3000 dairy farms have been closed. Also there is a trend into larger herds. According to the Statistiska Centralbyrån, the average herd size in Swedish dairy farms was 59 in 2009.

There are several models of AMS. Depending on the herd size milking systems are designed with one or more milking stall. Normally, each milking parlour is suitable for milking 60-70 cows. The capacity depends on the herd milk yield and number of milking per day. The AMS

market in Sweden is runned mostly by two companies, DeLaval (Sweden) and Lely (The Netherlands).

In AMS, cows are equipped with collar transponders which are connected to the computer via the receivers inside the barn. The cow activities such as milking time, daily milk yield, numbers of visits in the MS, eating time and amount of feeding are saved in the computer and used to control the cow traffic. These data also help the farmer to find out which cow has not been milked for more than 10-12 hours. These cows are normally fetched manually and directed to the MS.

Literature

Feeding

Feeding refers to the behavioural aspects of the nutrition process. There is a difference between feeding behaviour in the wild and in captivity. In the wild, feeding behaviour is accompanied by food-seeking behaviour. Also, food selection of animals feeding in the wild is more developed compared to those kept in barns. Cattle need to maintain their energy through food intake which includes carbohydrates, fats and protein. There are both external and internal factors motivating feeding behaviour. Smell of food, seeing other animals eating and sounds of other animals eating are examples of external factors. Physiological factors of the body are the internal factors stimulating motivation. (Mepham, 1995)

Feeding behaviour is one of the important aspects need to be consider when deciding about type of AMS. There are contradictory reports on effects of different traffic systems in quality and quality of feeding behaviour. For example, researchers found that dry matter intake does not differ between different types of traffic system (Ketelaar-de Lauwere, 1998) while others indicated decreased intake of concentrate and total dry matter in the barn applying free cow traffic in comparison with forced or guided cow traffic (Melin, 2007) or decline in number of visits to the feeding area in forced traffic system (Munksgaard, 2011). Melin (2005) indicated that these differences could be rooted in various conditions in the studies, such as feed management, palatability of the food, water availability, health and methods of measurement. Roughage has normally been distributed in feeding troughs by an automated feeder. Food has been available for the cows either in the resting area (resting area and feeding area are together) or in a separated feeding are located close to the milking stall. The cows have been able to reach the feeding area for a number of hours after milking.

Concentrate dispensers are usually located in the feeding area or in a special area just after exiting milking stall. There is a concentrate dispenser inside the MS to motivate the cows to enter the MS.

Cow traffic

Cow traffic refers to the specific patterns inside the barn which cows forced to follow. Accordingly, In an AMS cows are able to move between different parts of the barn, resting area, food section and milking stall in different ways depending on the barn design and they are supposed to plan their own milking schedule. (Ketelaar-de Lauwere et al. 1998) suggested that barn design influence numbers of visiting MU, feeding troughs and also number of times cows must be fetched.

A successful AMS has strongly relies on the number of cows voluntarily entering, exiting and daily feeding. The knowledge of interactions between cows and environment is vital to improve AMS. Cows need motivations to voluntarily visit the milking stall. Being milked considers as a weak motivation and it varied a lot between cows, however, eating consider as a strong stimulus (Prescott et al. 1998). Therefore, usually a concentrate trough exists in the milking stall. Another important factor is ease of access to the milking stall. (Melin et al. 2006) find out that wide waiting area near the milking stall reduce social competition for access to the milking stall.

Several automatic gates are separating different sections of a barn and they allowed either the cows pass in one direction or lock her inside a specific section, according to the cow's daily milk and/or feeding status.

Free cow traffic

In the free cow traffic system (Fig.1), there are no limitations on how the cows can move between different sections of the barn. Cows choose when and how often they eat or rest. The milking stall is always open unless when it washing up. Cows which enters the milking stall and been milked recently will be pushed out of the stall. The free traffic system is quite simple to design and therefore cheap to conduct.

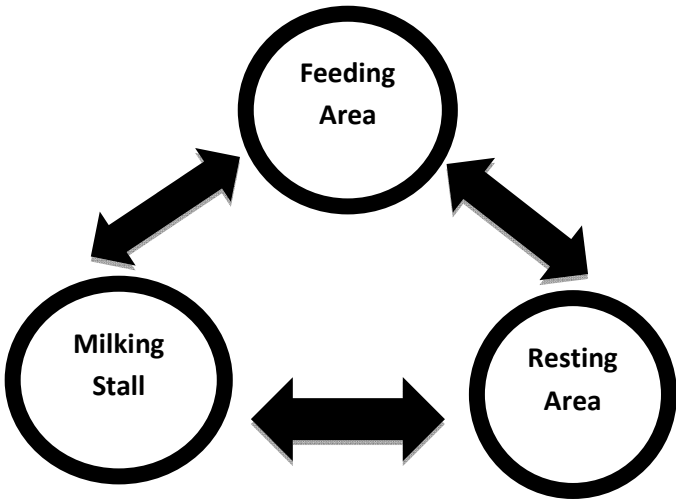

Fig.1. Free traffic system

Forced traffic system

In forced traffic system (Fig. 2), cow traffics are controlled with one way gate between stable sections. Cows which enter the milking stall but have been milked recently will be directly pushed to the feeding area. Forced cow traffic provides a good control of the cow traffic but then milking station will more often be occupied by cows not milked but still has to pass through it, so the milking capacity decrease and more often there is a line behind the milking stall. However, a shortcut between resting area and feeding area with a selecting gate that only let the cows being milked to pass.

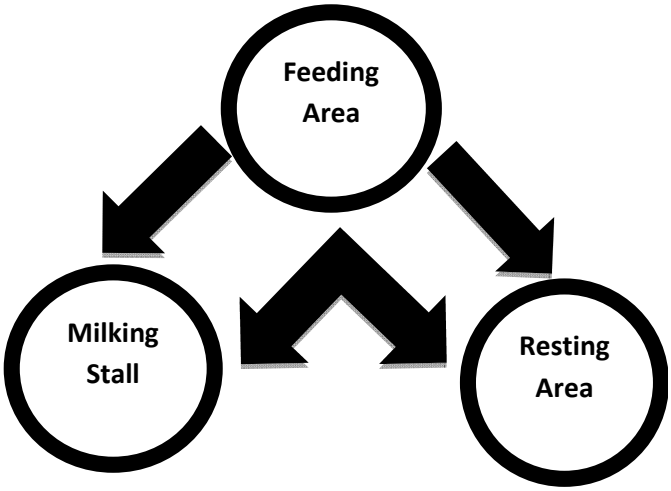

Fig.2. Forced traffic system

Effect of type of cow traffic on visiting MU

Some studies indicate that forced cow traffic motivates cows to visit MU more (Bach et al. 2009). However, more milking failure has been reported in the forced traffic situation. Moreover, the average successful MU visit between 2 systems was not notably different

(Munksgaard et al. 2011). In comparison between forced and free traffic system, 97.5% of MU in free traffic were successful while 89.7% of successful MU visit reported in forced traffic system (Gygax et al. 2007). Importance of large area in front of MU has been reported by several researchers in order to reduce the social competence for entering the milking stall (Melin et al. 2006). Overall, the best AMS design is the one which encourage voluntary milking as well as normal behaviour such as lying and feeding (Armstrong and Daugherty 1997).

Although voluntary visit of MU is an important factor to reduce farm labour, unproductive visit can decrease the milking efficiency. A study define that the time spent for exiting MU after a successful milking was shorter than a unsuccessful visit and also cow tend to re-entre the MU shortly after an unsuccessful milking. Moreover, cow spent more time exiting MU when another cow standing close to the MU exit gate compared with the time there was no cow standing around MU exit gate. Blocking MU exit gate can make the milking process on pause for a while since entering and exiting the MU is impossible. (Jacobs and Siegford 2012)

Controlling the milking frequency

Growing costs of labour consider as the most important reasons of development of AMS in many dairy countries. Conventional milking takes around 25-35% of the labour demand per year on dairy farms. Apart from lack of need of labour and substituting by robots, the quality of the life of farmers would undergo a major change since their regular presence for milking is not required any more. Therefore, labour demands reduction and better social life for the farmers are accompanied with improved animal health and well-being and increased milk productions.

Apparently, in a herd using an AMS, cows are milked more frequently in comparison with conventional milking system (CMS). Furthermore, frequent visiting of MU is considering as a parameter of successful AMS (K. de Koning 2002). The desire numbers of visiting MU by cows are 3-4 times per day and less than 2 times per day visiting of MU cause reducing in production and also increasing the risks of mastitis (Berglund et al. 2002).

Cows are known to acclimatize quickly to new equipment and environmental changes (Albright, 1981). Basically, AMS functioning according to a controlled voluntary participation of cows, while their attendance encourage by concentrate reward in the MU.

However, AMS equipped with a selection system which let the cows enter MU, feeding area or concentrate trough.

Milking interval varies a lot in a farm practicing AMS and can be short or extremely long. In a study conducted by (Mačuhová et al. 2003) average milking interval was 11.3 hours that means a frequency of 2.6 times per day. However, cows with less than 2 times visiting MU per day have to be fetched to be milked. In a study by (DeVries et al. 2011) a number of 15% of the cows needed to be manually brought to the MU for milking. Cows can prevent attending milking procedure due to several various reasons such as lameness, mastitis, injured animal, injured udder or teats, cow inexperience and status of social ranking. Food is using as a reward to motivate the animal to visit AMS. However, food is not a motivator for all the cows. (Rousing et al. 2006) reported that high producing cows consume a large amount of concentrate during milking in AMS that encourage them to go to the MU more frequently. On the other side, (Prescott et al. 1998) indicates that low producing cows did not increase their rate of attendance when fed so feed is not a good motivator for them. Subsequently, prolonged interval cause a negative effect on milk production (Aydi, 2003) and could be an indication of health problem. On contrary, short interval causing greater production of milk and also increase fat and protein (Erdman, 1995). Increased milk frequency from 2 to 3 times per day may cause 6-25% increase in milk yield per lactation (Klei et al. 1997). These differences in milking interval are linked to the cow related factors such as social dominance, motivation to be milked, udder's pressure and health status. (D.-J. de Koning 2006) found that heritability of milking frequency was 0.18 that is good sign for selection of cows with short milking interval.

Each time of milking require the cow's teats cleaned with warm water, dried, milked and disinfected. These procedures could have a negative effect on teat and udder condition. Also, milking with short intervals does not let the teat tissues to recover after each milking (Dam Rasmussen et al. 2001).

AMS is based on milking of the one single quarter than individual cow in other techniques. Therefore, production and health of each single cow can be observed in detail. Also, AMS facilitate farmer's assessments of various aspects of cow's health such as; SCC and colour. Another advantage of AMS is the potential of early detection of disease or nutritional issues since they record every small changes of every single cow. the farmers This is an advantage to teat condition and udder health when focusing on mastitis detection and also not over milking of front quarters (Dam Rasmussen et al. 2001).

Preparing the best AMS barn condition that help voluntary cows approach to the MU is not a guarantee that cow fetching in herd become infrequent. Fetching is more happening during the first 14 days of lactation which cows are learning how to use the AMS. After this period depending on the quality of the herd, between 4 to 25 % of the cows must be fetched at least once a day. In a survey carried out in Canada, 2.5% (the 5 best herds) to 42% (the 5 worst herds) of cows been fetched once or twice per day (Rodenburg, 2007). Although according to the farmers fetching does not take much effort it can make the cost of labour unexpected (Bach et al. 2007). In order to find out if the Aversive milking by AMS is the reason of needed to be fetched; Rousing et al. (2006) find no significant differences between fetched and non-fetched cows in case of stepping, kicking and avoidance of handler during milking. However, cows showed more avoidance space to the familiar handler.

Standing and lying

The importance of standing lying behaviour patterns in dairy cows especially after milking is the reduction in the risk of intramammary infection (IMI). In a study (Barnouin et al. 2004) in France indicate that cows been locked up to the feeding area without possibility of lying after milking were having very low Somatic Cell Count. In another study (Peeler et al. 2000) the incident of Mastitis was lower in the herd were given fresh feed after milking both in the morning and afternoon.

Welfare of dairy cows can be affected by various factors such as; social interaction with conspecifics and human, feeding, drinking, climate and barn design. In AMS, cows have more control on their activities and rhythm. For example, they choose the milking time and also lying and eating. However, milking stall in AMS design for one cow at a time and this isolated milking experience can lead to increase stress respond in dairy cattle (Rushen et al. 2001).

Forced cow traffic leads to appearance of long queues which can have impact on welfare of cow, particularly in low social rank cows. Making adequate motivation available for cows to approach, enter and exit from the milking stalls require sufficient knowledge of cow behaviour, otherwise, it affect the cows welfare.

The main welfare problem of AMS is related to the cows with low social ranking which are not approaching MU voluntarily or with long milking intervals. This cows need to be control by the staff and guide to the MU at least twice a day. However, the problem with the short milking interval is prevented through computer system and data transferring after each milking section (K. de Koning 2002).

Social rank

Dominant generally refers to an animal restrain a single or a group of conspecifics from access to the resources (Beilharz and Zeeb 1982). The factors that helping cattle to express dominance relation to the others are such as; age, numbers of lactation, body size, weight, production status (Friend and Polan 1974) , health and in the cattle raising in non-industrial condition, existence of horn. Although, any changes in these factors may lead to change in the direction of dominance relationship. For example, a dominant huge cow after several calving due to some physiological problem start to losing weight and change in body posture (Beilharz and Mylrea 1963) may not be dominant any more to the cow she used to be superior. Limited resource such as food, water, space etc. consider as environmental factors of appearance of dominance relationship. According to the fact that production level in dairy cows is highly linked with nutritional status, a strong correlation between social rank and production would be expected since social rank mostly appeared and influences priority of access to the animal basic needs (Syme 1974).

Cow in order to form a hierarchy in the group use various types of behaviour such as; stare each other in the eyes, gesture or more aggressive behaviour such as; butting head to head, head to side, head to back and pushing each other. However, the physical aggressions only observe in the newly formed herds or when one or several new cow added to the herd (Keeling and Gonyou 2001). As aggressive interaction usually ends at minor or severe injuries and also the behaviour takes a lot of energy, cows tend to avoid aggression (Lindberg 2001) and it is more observed in pregnant cow (Beilharz and Zeeb 1982).

A dominance- subordinate relation last for a long time after being established (Sambraus 1977) and since this relation can cause deprivation of subordinate side from access to resources, management system is the only way to cut this connection by changing the members of the groups.

In the wild dominant animals have a leading role to protect the group from invaders and also help the group to finding resources such as food and water. These qualities temp the subordinate animal to stay in the group while this the hierarchy in group change during the time and a subordinate animal can be a dominant one in future (Lindberg 2001). The hierarchy system in captivity varies a lot compare to the wild condition. In this condition low rank cow has not chance to leave the group and clearly it leads to appearance of aggressive behaviours (Keeling and Gonyou 2001). Also there is no threat for the high ranked cow like those existing in the wild, so the chances of changing hierarchy within group are minor.

Therefore, if we add the factors such as better access of dominant cow to food, water and resting place, it become more obvious that subordinate cow receive less welfare compare to high ranked (Phillips and Rind 2002). Also, the hierarchy in the group can have economic effect in farm management as high rank cow usually produce more milk and consume more food especially when there is limited access to the food (Albright and Arave 1997). Low ranked cow adjusted their eating situation better than high ranked cow when there is high completion for the food(Olofsson 1999). Although, cow tend to be less active during the night and mostly lay down but low ranked cow lay less in the crowded barns(Wierenga and Hopster 1990).

Animal with the same level of dominance value encounter each other more in order to prove themselves to each other (Phillips and Rind 2002), while (Albright and Arave 1997) says that dominant animal tend to face other conspecifics more. Although many forms of hierarchy are linked together but the hierarchy system can be vary between resources such as feed, water, space and partnership (Phillips and Rind 2002).

Access to resources count as a main reason to appearance of aggression in an established herd. However each individual may prioritise recourses in different way according to her needs. For example, a high producer cow is more motivated to milked and reduce the udder pressure compare to a low producer one. Also, receiving incentives such as concentrate in the milking station is another factor which is more favourable for the high producing cows since they get hungrier as they produce more. (Phillips and Rind 2002)

Researches about relation between dominance value and age and body weight shows a very different results. (Kabuga 1992; Lauwere et al. 1996) found no correlation between dominance value and cow age while (Albright and Arave 1997; Friend and Polan 1974) find a significant correlation between age and dominance value in cattle. In case of body weight, (Collis 1976; Kabuga 1992) found no correlation while on the other side(Albright and Arave 1997; Beilharz et al. 1966; Friend and Polan 1974) found a significant correlation between body weight and dominance value.

Although in AMS cow have more control in their daily routines but it is not the same for all the cows. Lower-social ranked cows choose their milking time depending on other cows activity (Hopster et al. 2002). Therefore, the lower-ranking cows are known to be responsible for irregular milking interval (Hogeveen et al. 2001). Waiting time for AMS differs significantly between Lower-ranked cows and higher-ranked cows. Halachemi (2009)

indicated that lower-ranked cow spent 68.9± 6.5 min while higher-ranked cows spent 3.5± 0.1 min in the line.

The aims of this study were to study: 1) the cows' interactions before and after the MU and the relationship between the cow's social rank preference of choosing cubicle in the resting area.

Material and method

This project includes two different experiments; cow behaviours in Automatic Milking System (AMS) and location preferences of cows in the resting area. The experiments were conducted during March and April 2011 by using 88 Swedish Red Breed dairy cows at Kungsängen Research Centre, Uppsala, Sweden.

Cows and situations

The cows were housed in two different barns (E Barn and F barn) with loose housing systems deferring in design. The herd was let out on pasture during the summer. However, during this study conducted the cows had been kept indoor for over six months and acclimatized completely. Cows might be transferred from one barn to another once during winter or stay the whole period in the same barn. The age of the cows ranged from 1 to 5 years. Both barns were equipped with robotic milking units (DeLaval^{TM} VMS, Sweden), the cows were milked in average 2.5 times/day. Those cows that had not been milked during 14 hours were fetched by the staff. Excluding cleaning and maintenance, the milking unit was opened for milking 22 hours a day. Cows had unlimited access to the roughage and water. The amount of concentrates consumed by cows was measured by collar band transponder. The concentrates troughs placed in different locations in the barns. Automatic manure removal system operated regularly. Moreover, inaccessible area by the manure removal bar, cleaned by staff once a day. Also the milking unit closed by staff once a day for cleaning. The process of cleaning usually took about 30 minutes. Moreover, the barn floors were covered by rough concrete and the cubicles' surface covered by rubber mats and cut straw on top which was renewed on a daily basis by staff.

E barn

The barn include 6 different sections as follow: Milking unit, waiting area, feeding area, selecting gate, resting area and office (Fig.1). The resting area held 56 cubicles in 4 rows. In the middle section there were 28 cubicles, 2 line with 14 cubicles each, placing head to head and a wooden board in between made the cubicles hidden from the other side and 16 cubicles in each side of the barn heading the wall. There were a concrete alley in between the side and middle rows. There were 4 active water bowls in the resting area, two of them at the front close to the controlling gate and two other at the end of the barn. A cleaning cow brush was working 24 hours a day. The only access to the milking unit was through passing one of the two control gates which were located at the beginning of the alleys. Basically, cows at the gate encountered three different situations concerning their milking and feeding status, whether leading to the waiting area for milking, to the feeding area for or run into closed gate due to lack of milk in udder or over visiting of feeding area. The waiting area had a $40m^2$ surface and capacity of placing up to 11 cows. The floor was made of rough concrete. Entering milking unit was voluntary and mostly depend on the status of domination or the locations cow placed. Process of milking took normally 12 minutes including cleaning cluster, washing teats, placing teat cups and milking but the milking time vary depending on cow production and time spending by machine to place teat cups. There were feeding areas on each side of the milking unit and cows were leading by automatic gates to every other side (ex. first cow to the left side and second cow that were leaving the MU to the right side). In the feeding area according to their state of feeding they can consume roughage and/or concentrates. In each feeding area 10 roughage trough and one concentrate trough were available. There were two water bowls in each feeding area and water was constantly available to drink. There was a one-way gate from the feeding area to the resting area in each side.

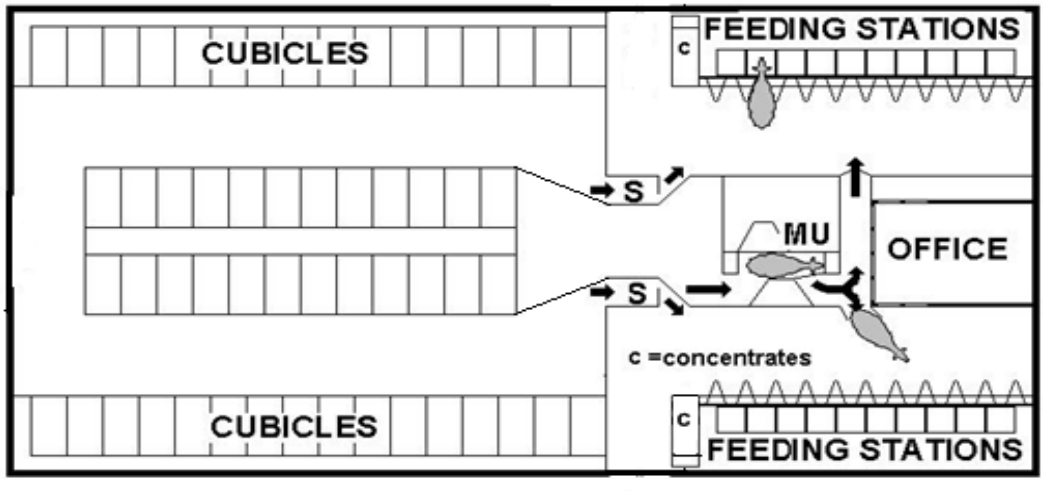

Figure 3 E barn floor plan

F barn

The barn was divided in 5 different sections. The resting areas were the biggest part in the barn and include 40 cubicles containing roughage trough, water bowl and salt block. The only access to the milking units was trough passing the waiting alley that had the capacity of 5 cows standing in line. When a cow entered the alley, there were no way out unless passing the milking unit then concentrates area and finally passing one-way gate to the resting area. When a cow went into the milking unit, she was recognized by the system via collar band transponder. In case she was milked during the past 6 hours, the machine was running otherwise the gate to the concentrate area opened and weather habitually or the pushing of the back cow one the line, she entered the concentrates area. Concentrates area had capacity for 3 cows (up to 7 cows in unusual situation such as existence of an aggressive cow, blocked exiting gate or malfunctioning machine) finally, maintenance area which was surrounded by resting area, waiting alley, milking unit and concentrate area.

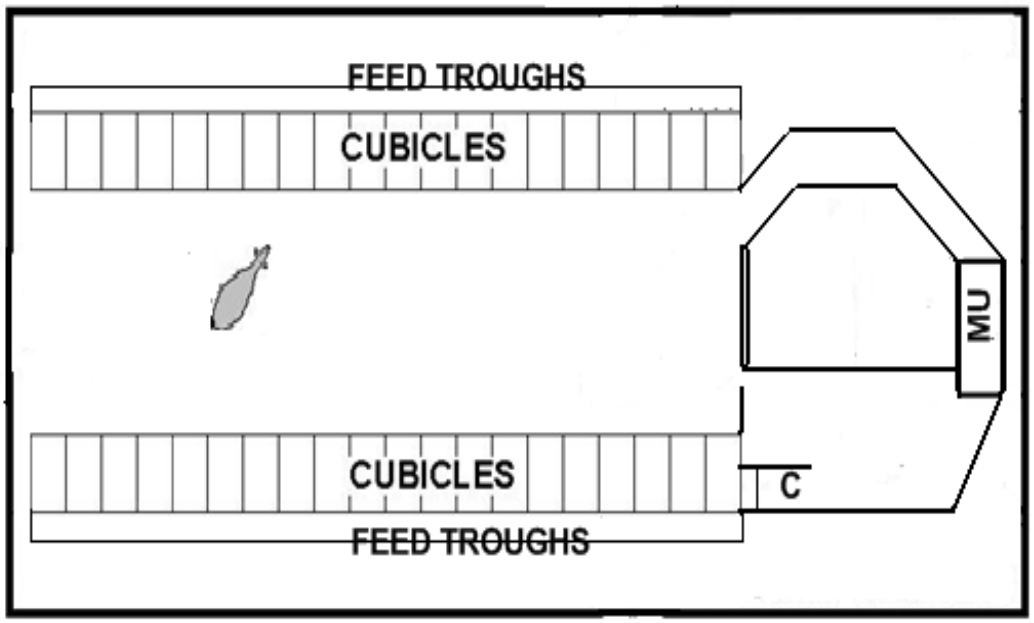

Figure 1 F barn floor plan

Measurements

In the first experiment, aggressive behaviour was measured by the whole day continuously live observation. The behaviours observed included; pushing, butting (head to head, head to side, head to rear) and blocking (blocking refers to the behaviour of standing in front or pushing the feeding area gate and do not let the other cows passing the gate.

The continuous aggression or repeated the same sort of aggressive behaviour between two cows, were counted as one. These behaviours were observed in resting area, concentrate area, waiting line, waiting alley and feeding area. At least, 72 hours of live observation in both barns was applied. Each day divided in 6 periods of 4 hours and observation took place at least 3 times for each of the 4hour-period. In total each barn were observed more than 3 days.

In a second experiment, the preference of cow in choosing cubicles and the behaviour at the time of placing in the cubicles such as lying, standing were measured. The status of roughage existing in the troughs of F barn was recorded as motivating parameters in choosing a cubicle. The cubicle occupation and cow's condition including standing or lying and also feed availability in troughs were recorded once an hour.

Calculation of dominance value

F barn

Dominance value in F barn calculated through direct observations of interactions between cows inside the concentrate area, in the resting area and waiting line which has done by the author.

E barn

Dominance value in E barn calculated through the behaviour in front of the roughage troughs, milking interval and time spent in WA per milking. We used the data from the barn's computer in order to evaluate the dominance value.

Statistical analysis

In this study the statistical analysis were performed using the SAS/STAT® software (ver.9.2, Cary, NC, USA). The procedure been used in this are MEAN procedure, FREQ procedure, GLM procedure and UNIVARIATE procedure.

Results

F barn

Effect of feed availability in troughs on distribution of cows in the barn

Amount of feed on troughs were categorized in 3 groups. Group 3 was a trough newly filled, group 2 a trough with approximately half of the feed remained and group 1 was almost empty one.

Totally, in 936 samples, 66% of cows were in cubicles with half full trough, 23% in the cubicles with empty troughs and 11% in cubicles with troughs newly filled.

There was no significant effect of amount of feed in trough on distribution of cows in cubicles and lines. In total observations, 26.6 % of the cows were in a cubicle with an empty trough, 26.2% in a cubicle with a full trough and 25.2 % were in a cubicle with a half full trough.

In 524 samples from line 1, 57% of the total herd when the trough were empty, 56% when the trough was half full and 54% at the time that trough were filled newly, were existed at the cubicles. Also, in 412 samples from line 2, 42%, 44% and 46% of total herd were existed in cubicles with empty, half full and full trough, respectively.

Row and cubicle preference in F barn

In 936 samples, cows prefer row 1(row on the right side of milking unit) to row 2. In total, 56% of the times, row 1 were occupied however, row 2 were occupied in 44% of all observations.

The total percentages of each cubicle's occupation varied significantly between 19-94% of all observations. Also, in line1, cubicles were occupied in 72% of the observation and corresponding figure for the cubicles in line 2 was 58%.

Standing and lying

In total, in row 1, 8% of the cows and 6% of the cow in row 2 were standing. Also, in row 1, 7% of the observations and in row 2, 5% of the cows were lying.

In 9% of the observation the cows were standing if the troughs were full, corresponding figure were 7% and 5% when troughs were half full and empty respectively.

Moreover, 8% of the cows were lying in the cubicles with empty troughs, 6% of lying cows were in the cubicles with half full troughs and 4% of cows were lying in cubicles with troughs full of roughage.

Day time and effect on standing and lying

We divided a day into 4 parts as follows: 00.00-05.59, 06.00-11.59, 12.00-17.59 and 18.00-23:59. It illustrated that except the time period between 00:00 to 05:59 which 72% of the cubicles were occupied; there were not major differences of cubicles' occupation in other times of the day. The percentage of cubicles that were occupied from 06.00-11.59, 12.00-17.59 and 18.00-23.59 was 65%, 63% and 64%, respectively.

In terms of standing, between the hours 06:00-11:59, 42% of cubicles were occupied by standing cows, 39% between the hours 12.00-17.59, 31% between the hours 00:00-05:59 and 39% of cubicles between the hours 12.00-17.59 were occupied by standing cows, in all observations.

On the other side, major cubicle occupation with lying cows took place between the hours 00:00-05:59 by 57% of all observations. Also, 38% of the cubicles between the hours 18:00-23:59, 30% between the hours 06:00-11:59 and 28% between the hours 12:00-17:59 were occupied by the lain cows.

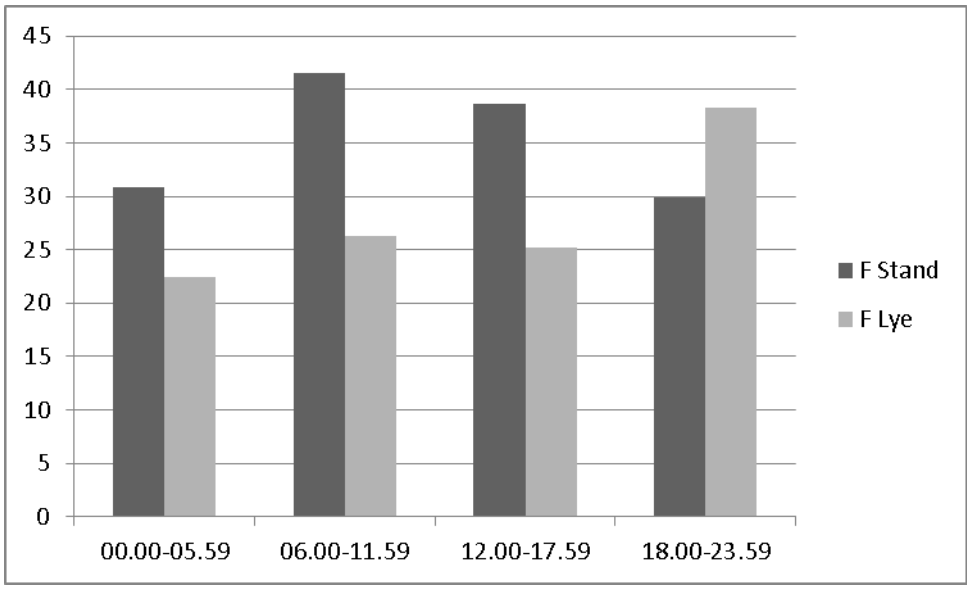

Figure 5 Standing and lying pattern in F barn according to the different time of the day

Lying or standing preferences in line 1 and line 2

Thirty-eight % of the cows in row 1 were standing while 32% of the cows were standing in row 2. According to the time separation, the highest percentage of cow stand was observed at hours 06.00 to 11.59 and the lowest percentage of the cows were standing between hours 18.00-23.59. Also 39% of the cows were standing between the hours 12.00-17:59 and 31% of the cows were standing from 00:00-05:59.

The lying behaviour was observed more in row 1 with the percentage of 40 and 37% of the cubicles were occupied by the cows which were lying.

Due to the day separation, a significant number of the cubicles were occupied by cows which were lying between the hours 00.00-05.59 with 57%. The percentages of cubicles were occupied by laying cows between the hours 18:00-23:59, 06:00-11.59 and 12.00-17.59 were 38%, 30% and 28%, in order.

Relation between time spend in WA or C and dominance value

The time spent in concentrate area and dominance value has contrary relations. In other word, there was a tendency ($P<0.055$) that the higher dominancy value, the shorter time spent in concentrate area. However the time spent in the waiting alley and dominance value did not show any significant relationship.

E barn

Standing and lying preference between different rows

Standing patterns of the cows in different rows did not show a significant preference by cows. In total observations, 13.2% of the cubicles in row 1 were occupied with the cows were standing. The percentage s of cow that were standing in other cubicles were as follows; 12% in row 2, 13 % in row 3 and 11.8% in row 4.

In terms of lying, cows showed a slight preference of row 1 and 4 in all the observations. 54 % of the cubicles in row 1 were occupied by the cows were lying and 53% of the cubicles in row 4 were occupied by the cows which were lying. In row 2 and 3, 49% and 47% of cubicles were occupied by the cows were lying.

Day time and effect on standing and lying

We divided a day into 4 parts as follows: 00.00-05.59, 06.00-11.59, 12.00-17.59 and 18.00-23:59. It illustrated that except the time period between 00:00 to 05:59 which 64% of the cubicles were occupied; there were not major differences of cubicles' occupation in other times of the day. The percentage of cubicles that were occupied from 06.00-11.59, 12.00-17.59 and 18.00-23.59 was 59%, 56% and 58%, respectively.

In terms of standing, between the hours 06:00-11:59, 26% of cubicles were occupied by standing cows, 25% between the hours 12.00-17.59, 22% between the hours 00:00-05:59 and 21% of cubicles between the hours 12.00-17.59 were occupied by standing cows, in all observations.

On the other side, major cubicle occupation with lying cows took places between the hours 00:00-05:59 by 55% of all observations. Also, 43% of the cubicles between the hours 18:00-23:59, 42% between the hours 06:00-11:59 and 38% between the hours 12:00-17:59 were occupied by the lain cows.

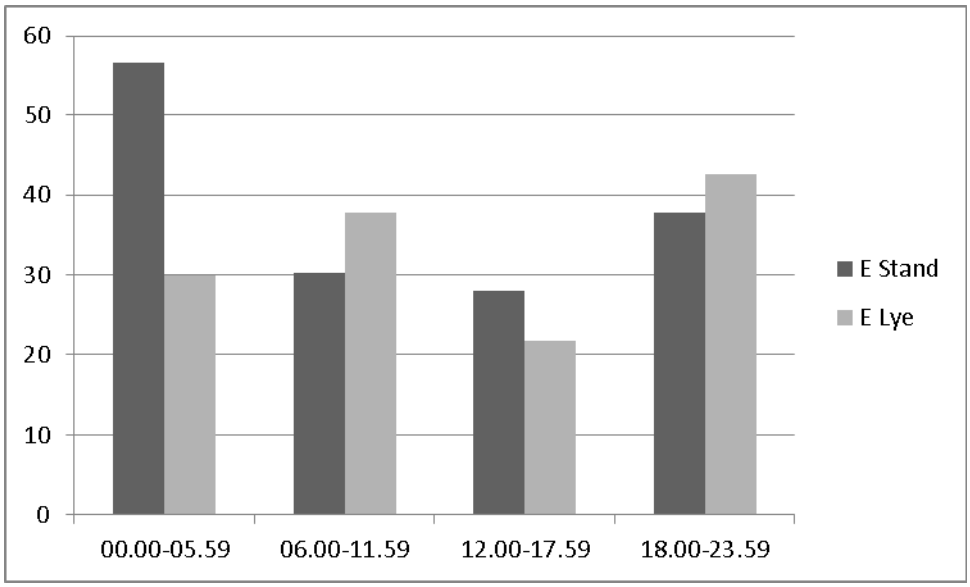

Figure 6 standing and lying pattern in E barn according to the time of the day

Row preference in E barn

There was a preference of the side rows close to the wall and among those the cows preferred the row on the right side of the milking unit. Also between the two rows in the middle of the barn, that one on the right side of the milking unit was used more often. In 1656 samples, 31% of the time cows occupied row 1(the row on the right side of milking unit and close to wall), 29% used row 2 (left side of milking unit close to wall), 20% row 3(middle section on right side of milking unit) and 19% in row 4(middle section on the left side of milking unit).

Cubicle preferences in E barn

Of the total observations, 64% of the cubicles in row 1(right side of milking unit close to the wall), 62% of the cubicles in row 4 (left side of milking unit close to wall), 57% of the row 3(cubicles on the left side of milking unit in middle) and 56% of the cubicles of row 2(right side of milking unit in middle) were occupied. The occupation of the cubicles been varied significantly from 10-92% of all observations.

Dominance value in relation to location and number of cows in waiting area

The waiting area divided in three parts in related to the distance to the milking unit: as follow close to, in the middle and far away from the milking unit. Also, the number of cows in waiting area was divided into three groups of 1-4 cows, 5-7 cows and more than 7 cows. In 195 samples, 50% of the cows were standing in middle of the waiting area, 31% close to milking unit and 19% in distance from milking area. In terms of number of cows in waiting area, there were more than 7 cows in 38% of the whole observations, 35% of the time with 1-4 cows and 27% of the time there were between 5-7 cows in waiting area.

There was a negative correlation between the dominance value and number of cows in the area close to milking unit and the rest of the waiting area. In the area close to milking unit, the more number of cows, the higher dominance value. However, in areas of middle and far from milking unit the numbers of cows decrease with increase of dominance value.

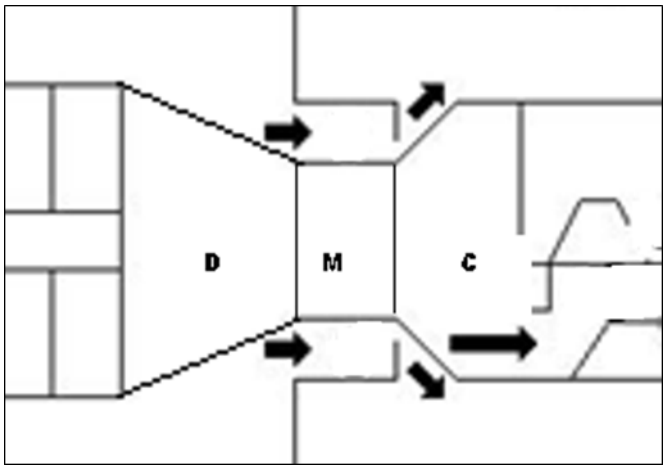

Figure 7 waiting area sections

Milk production

The daily milk yield differed between the two barns. In F barn, 50% of the cow were primiparous and the other 50% were older cows. The daily yield was 30.1 kg the first calvers and 34.5 kg for the older cows. In E barn, 39% of the cows categorized as the first calvers and 61% of the herd as the older cows .The daily milk yield varied between 37.6 kg (primiparous) and 43.8 kg (older cows).

Usage of cubicles

Comparison of the cubicles occupation based on the different times of the day between the barns showed a relatively similar steady pattern. Cubicles are mostly occupied early in the morning and during the last 6 hours of the day. Between these two periods, cubicles were less occupied. The ratio of the cubicles to cows in F barn was 1,05 (38 cows and 40 Cubicles) and the ratio of the cubicles to the cows in E barn was 1,10 (58 cows and 64 cubicles).

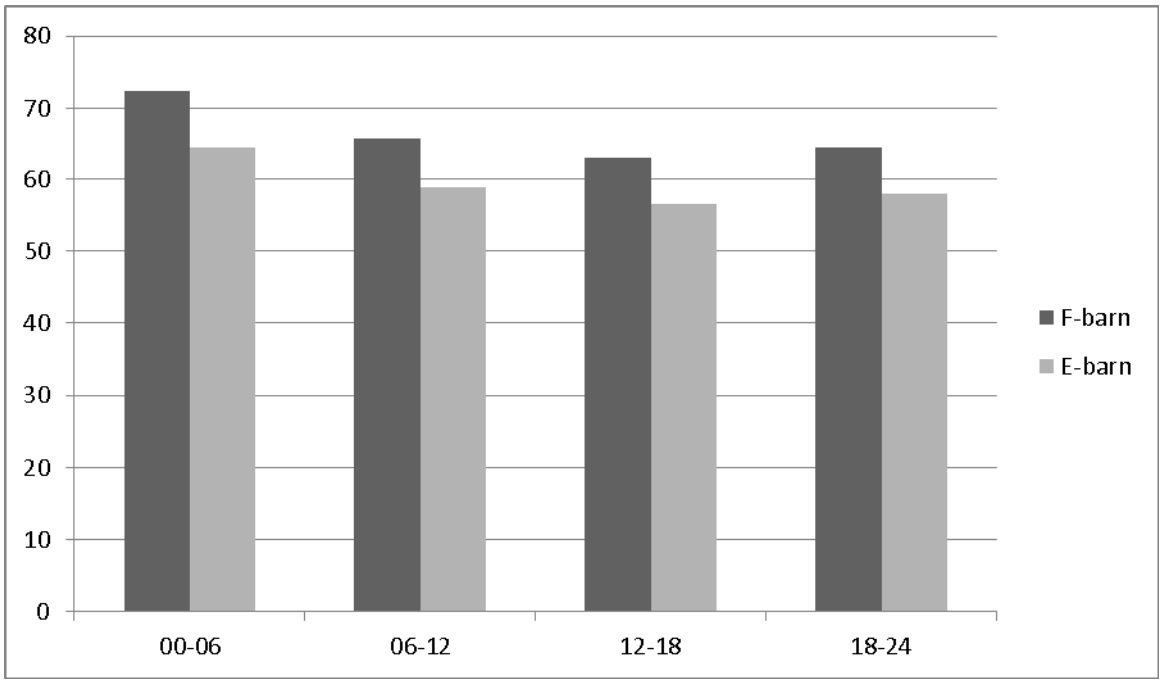

Figure 8 comparison of cubicle occupation in E and F barn in different time of the day.

Personal observations

Cow showed high number of aggressive and competitive behaviour after being deprived of resource(s) for a long time. For example, the milking unit closed twice a day for cleaning process which usually took 25min. Moreover, the milking unit was closed up to 45min when the staff cleaned the main milk tank. During cleaning time, the entrance gate to the milking line in F barn was closed manually while the entrance gate to the waiting area of E barn was open and as long as there was free space in the waiting area; cows could enter the waiting area if they were not milked recently. In F barn staff was waiting till all the cows passed the milking unit or manually evacuated the line then close the gate but in E barn those cows

which entered the waiting area already were waiting inside till the cleaning process finish completely.

Also, the robot needs to get regularly checked-up and the arm adjusted in order to speed- up the milking process and reduce the risk of damages to the teat by milking cups. This process reduced the milking pace and in some cases paused the process for a while.

The deprivation of cows from being milked and having access to the feed induced aggressive behaviour. Since the milking gate was closed, many cows gathered behind the gate and started pushing and heading each other to get to the front of the line. Accordingly the aggressive behaviours were continued with the same cows in the line and in few cases it even continued after being milked in the concentrate area.

Another problem which was observed during my experiment which may seriously hinder the system was blocking of the gates by one or several cows which interrupted the process of entering or exiting. In F barn the action of blocking gate usually take placed around concentrate area. One or several cows were blocking the concentrate area gate from outside and were stopping cows to leave the concentrate area. This action delayed the process because the concentrate area was fully occupied and there was not enough space for another cow to pass the milking unit to the concentrate area. In some cases the actions ended with help of staff.

Figure 9 Blocking concentrate area's gate (F barn)

In the E barn gate blocking were mostly happening around the waiting area and cows which were standing inside the waiting area close to the gate were blocking the gate in order not allow another cow to enter. The blocking of the gate delayed or paused the process of entering the waiting and feeding areas.

Figure 10 Blocking the gate to feeding area (E barn)

Distribution of roughage in F barn took-place twice a day so troughs could be emptied after a while (although some few troughs remain intact) and almost all the troughs were empty before feeding machine started to distribute roughage.

Distribution of roughage in F barn started from one side and ended at the other side. It normally took a couple of minutes for the machine to reach the last trough and by that time almost all the cow were eating from the trough located on the side of the barn which machine

started to distribute. This naturally led to fight and appearance of competitive behaviour in order to reach the trough first. In some cases three cows was observed in a cubicle designed for only one cow.

In the F barn, there was possibility for cows to visit milking unit several times in a short period of time without being milked. The continuous visit to the milking station was due to lack of possibility to consume concentrate because of another cow who was feeding concentrate or just watching it. This behaviour just observed in the cows which has not being milked for the first visit.

It has been observed that when cows leaving the milking unit to the concentrate area may seriously interrupted when another cow(s) were standing close to the gate facing the milking unit and usually caused appearance of aggressive behaviour and hinder the process. In some cases the aggressive behaviour influenced the line on the other side of the milking unit.

Discussion

Automatic milking systems have the possibility of increasing milk yield in comparison with conventional milking system (K. de Koning 2002). However, optimizing the system efficiency is crucial in order to fulfil the high starting cost. Milk production, frequency of milking, milking intervals and successful rates of teat-cup attachment are important aspects can increase efficiency of the system (Bijl et al. 2007). These factors can be interrupted by cow's characteristic and behaviour beside technical errors.

Line/ Waiting Area

Cows with high social rank spent less time in closed areas(waiting area or concentrate area) compared to cows with low social rank status (Melin et al. 2006). In the F barn, cows with higher social rank pushed the other cows away from the concentrate trough or butted them the entire the time they been consuming concentrate. In some cases lower ranked cows left of the concentrate area immediately after exiting milking station by dominant cows force. The appearance of aggressive behaviour in some cases hindered the whole milking process since the cow stayed still inside the milking station after been milked due to the unstable situation in the concentrate area. Although, there were no significant differences of DV in the waiting line in the F barn due to the design, cows with higher DV spent less time in concentrate area. Cows with higher social rank tended to spend less time in the waiting area.

Resting area and Cubicles

There was a strong preference for the cubicle line in the E barn. The cows preferred more the two rows close to the wall compare to the rows in the middle and avoided cubicles in both ends of the middle row, probably because many cows passed these cubicles. Another reason why cows preferred the rows to the side could be that the selecting gates towards the waiting and feeding areas were located close to the rows in the middle and cows usually walked towards the gate with high motivation for being milked or consuming feed. This motivation was higher than finding a free cubicle therefore; cows walked towards the gates always win the interaction. This situation can lead to form an imaginary traffic flow in the barn which made the cubicles on the side rows easier to choose by the cows.

In the F barn the existence of roughage troughs and the amount of roughage in the troughs had low effect on cubicle occupation.

Lying and standing pattern

In the E barn, cows tended to lie more than cows in the F barn. Although, lying pattern in the early hours of the day and also in the end of the day followed relatively same percentages of number of lying cows, it varied in the hours between 6 in the morning till 18:00. In total cows lying pattern in F barn shows lower percentage and it is due to the fact that in F barn, roughage troughs are inside resting area and cows spending both resting and consuming roughage in the cubicles. This may affect the percentages of periods which cows were standing inside the cubicles. On the other side, in the E barn, cows used the cubicles just to rest and this behaviour took place mainly when the cows were lying down.

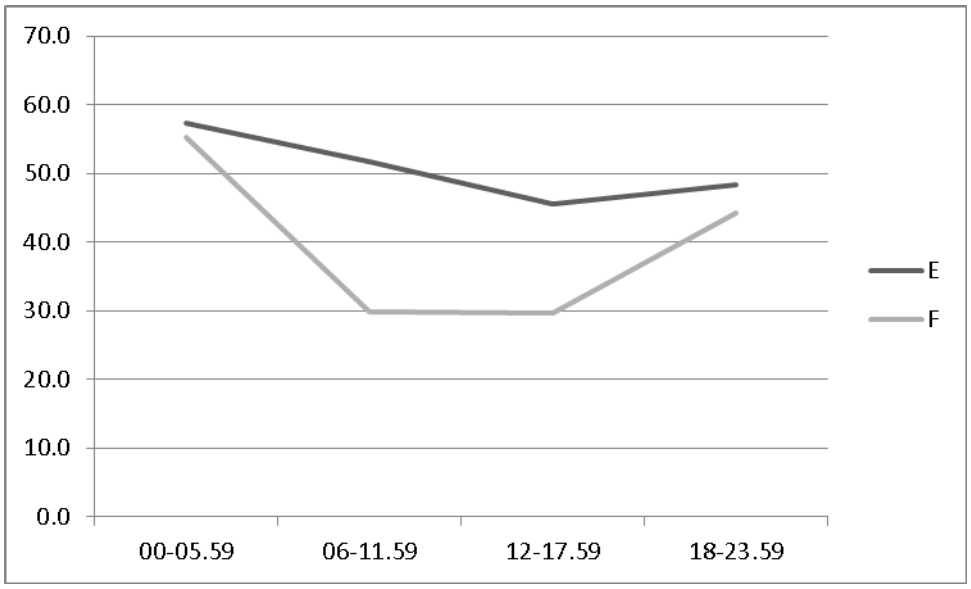

Figure 11 comparison of lying pattern in E and F barn in different times of the day

There was a significant difference between the cows standing patterns between the barns. In the F barn, there was about a 25% increase in the percentages of standing behaviour in the hours between midnight till middle of the day while percentages of stand cows in the E barn showed 2% increase and this followed a steady trend entire the day. Cows showed the minimum amounts of standing behaviour in the early hours of the day in both barns.

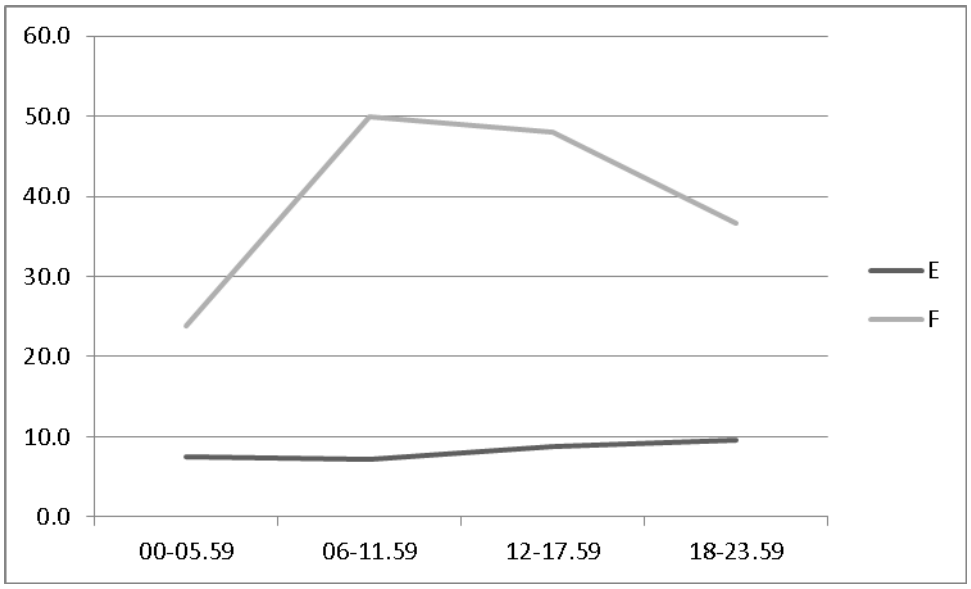

Figure 12 comparison of standing pattern in E and F barns in different times of the day

Barn Design

Dairy barn design should provide the best environment, resulting in good welfare and to allow cows to maximize their milk production. Efficiency of the cow traffic system has a direct effect on the total number of milking in the system and increase the system capacity. To obtain the maximum potential of automatic milking system, it is important to efficiently guide the cows and possibly reduce the competitive behaviour for resources.

Comparison of two different systems (E barn and F barn), the time spent in waiting alley (F barn) was slightly lower than the time the cows spent in the waiting area (E barn). The F barn waiting alley was designed in a way that eliminated the chance for high ranked cows to cut in the line and push back the low ranked cows back in order to enter the milking station rapidly. However, in a few cases, cows due to the prolonged milking process or milking machine failure, tried to walk backwards and push back the cows standing behind in order to get out of the line. Also, effects of DV in form of appearance of aggressive behaviour were observed before cows entering the waiting line especially when two or more cows aim to enter the line simultaneously. On the other side, In the E barn waiting area, the effects of DV was more obvious. The waiting area of the E barn with an area of $40m^2$ had the capacity of 8-10 cows and it let the cows to choose the location of standing in the area. Cows with high DV normally walked towards the milking station as they entered and in cases there were high number of conspecifics available in the waiting area, they start to compete for the space. Therefore, cows with lower social rank pushed back to the far ends of the area and usually they stand there as long as the number of cows in the waiting area remained high.

On the other side of the milking unit, the effects of social rank was more frequent in the F barn than in the E barn due to the size of the concentrate area and also the number of concentrate troughs in the F barn. Concentrate areas in the F barn had a maximum capacity of 3 cows at a time, while in some cases three times that normal number of cows were observed which caused quite high numbers of aggressive behaviours. This overcrowded situation usually occurred due to blocking of the gate from outside by the cows trying to enter the concentrate area without passing the waiting line and milking station. An overcrowded concentrate area leads to an interruption of the milking process and also aggressive behaviours in the line. In the E barn, due to the existence of several roughage troughs and wider space compare to the F barn which allowed the cows to keep distance from each other or escape from each other in order to avoid aggression, less aggressive behaviour were observed.

Milk yield

In spite of the better access to roughage and less complicated milking procedures in the F barn compared to the E barn (separated feeding and resting area, existence of automatic gate between resting area and feeding area and possibility of appearance of competitive behaviour inside feeding area and waiting area), there was a higher milk yields in both groups of first calvers and older cows in E barn. In E barn, there was a better and calmer access to the concentrate troughs. There were 2 troughs with a protection door placed in the feeding area for serving about 58 cows while in F barn there was only one concentrate trough without protection door for serving about 38 cows.

Conclusion

One of the biggest advantages of AMS is reducing the cost through less need of labour work. Therefore, effort should be on ways to reduce all forms of discomfort for the animals and also ease the movement of cow inside the AMS barn so the animals can access the resources easily and go through the MU anytime they need. The barn design plays a significant role in order to help the animal to follow their "routines". In this study it was seen that the size of the concentrate area may affect the appearance of aggression. The size of the area may vary depending on the number of the cows in the herd but we suggest that it should have at least a capacity to allow 5-7 standing at the same time in a standard AMS herd.

In this study blocking the exit gate was observed as a big problem that could delay or stop the whole system. It caused aggressive behaviours and also some animal injuries. Basically, cows that were blocking the gate, tried to enter the concentrate area without passing through the waiting line, milking station and then concentrate area. We suggest a new design of the gate which makes it easier and takes less energy for the cow standing inside the concentrate area to push the gate and exit.

Distribution of the feed was another reason to cause aggressive behaviours. When the feed distributer started (especially in the morning), all the cows rushed to the side which machine started to distribute feed at. It is important to adjust the distribution in the way that the roughage through is not empty for a long time and to eliminate factors which may push back cows from staying at a cubicle such as; darkness, sounds, temperature. Also distribution of roughage simultaneously from both sides can reduce the rush towards on side's cubicle and reduce completion accordingly.

Existence of cubicle close to the gates causes interactions between cows. A significant competition between cows was observed when they wanted to enter waiting area or waiting line. The cow that lost the competition started to find a cubicle or consume roughage in a safe place. Moreover, when cows wanted to exit from of the cubicles close to the enter or exit gates that might encounter a severe attack from other trying to enter the waiting area or just leave the concentrate area.

References

Albright, J. L. and Arave, C. W. , 1997. *The behaviour of cattle* (The behaviour of cattle.; Wallingford, UK: Cab International).

Armstrong, D. V. and Daugherty, L. S. , 1997. Milking robots in large dairy farms. *Computers and Electronics in Agriculture.* 17 (1), 123-28.

Bach, A., 2007. Effect of Amount of Concentrate Offered in Automatic Milking Systems on Milking Frequency, Feeding Behavior, and Milk Production of Dairy Cattle Consuming High Amounts of Corn Silage , *Journal of Dairy Science.* 90 (11), 5049-55.

Bach, A., 2009. Forced traffic in automatic milking systems effectively reduces the need to get cows, but alters eating behavior and does not improve milk yield of dairy cattle. *Journal of Dairy Science.* 92 (3), 1272-80.

Barnouin, J., 2004 . Management Practices from Questionnaire Surveys in Herds with Very Low Somatic Cell Score Through a National Mastitis Program in France. *Journal of Dairy Science.* 87 (11), 3989-99.

Beilharz, R. G. and Mylrea, P. J., 1963. Social position and movement orders of dairy heifers, *Animal Behaviour.* 11 (4), 529-33.

***Beilharz, R. G. and Zeeb, K., 1982. Social dominance in dairy cattle. Applied Animal Ethology. 8* (1–2), 79-97.**

Beilharz, R. G., Butcher, D. F., and Freeman, A. E. , 1966. Social Dominance and Milk Production in Holsteins. *Journal of Dairy Science.* 49 (7), 887-92.

Berglund, I., Pettersson, G., and Svennersten-Sjaunja, K. , 2002. Automatic milking: effects on somatic cell count and teat end-quality. *Livestock Production Science.* 78 (2), 115-24.

Bijl, R., Kooistra, S. R., and Hogeveen, H. , 2007. The Profitability of Automatic Milking on Dutch Dairy Farms. *Journal of Dairy Science.* 90 (1), 239-48.

Collis, K. A. , 1976. An investigation of factors related to the dominance order of a herd of dairy cows of similar age and breed. *Applied Animal Ethology.* 2 (2), 167-73.

Dam Rasmussen, M., 2001. Udder health of cows milked automatically. *Livestock Production Science.* 72 (1–2), 147-56.

de Koning, K. , 2006. Conflicting candidates for cattle QTLs.*Trends in Genetics.* 22 (6), 301-05.

de Koning, K. ,2002. MILKING MACHINES - Robotic Milking, in Roginski Editor-in-Chief: Hubert (ed.). *Encyclopedia of Dairy Sciences* (Oxford: Elsevier). 2038-45.

DeVries, T. J., 2011. Association of standing and lying behavior patterns and incidence of intramammary infection in dairy cows milked with an automatic milking system. *Journal of Dairy Science.* 94 (8), 3845-55.

Friend, T. H. and Polan, C. E. , 1974. Social Rank, Feeding Behavior, and Free Stall Utilization by Dairy Cattle. *Journal of Dairy Science.* 57 (10), 1214-20.

Gygax, L., 2007. Comparison of Functional Aspects in Two Automatic Milking Systems and Auto-Tandem Milking Parlors. *Journal of Dairy Science.* 90 (9), 4265-74.

Hogeveen, H., 2001. Milking interval, milk production and milk flow-rate in an automatic milking system. *Livestock Production Science.* 72 (1–2), 157-67.

Hopster, H., 2002. Stress Responses during Milking; Comparing Conventional and Automatic Milking in Primiparous Dairy Cows. *Journal of Dairy Science.* 85 (12), 3206-16.

Jacobs, J. A. and Siegford, J. M., 2012. Invited review: The impact of automatic milking systems on dairy cow management, behavior, health, and welfare. *Journal of Dairy Science.* 95 (5), 2227-47.

Kabuga, J. D. , 1992. Social interactions in N'dama cows during periods of idling and supplementary feeding post-grazing. *Applied Animal Behaviour Science.* 34 (1–2), 11-22.

Keeling, L. J. and Gonyou, H. W. , 2001. *Social behaviour in farm animals*, eds L. J. Keeling and H. W. Gonyou (Social behaviour in farm animals; Wallingford, UK: CABI Publishing).

Ketelaar-de Lauwere, C. C., 1998. Behaviour of dairy cows under free or forced cow traffic in a simulated automatic milking system environment. *Applied Animal Behaviour Science,* 56 (1), 13-28.

Klei, Linda R., 1997. Influence of Milking Three Times a Day on Milk Quality. *Journal of Dairy Science,* 80 (3), 427-36.

Lauwere, C. C. Ketelaar-de, Devir, S., and Metz, J. H. M. , 1996. The influence of social hierarchy on the time budget of cows and their visits to an automatic milking system. *Applied Animal Behaviour Science,* 49 (2), 199-211.

Lindberg, A. C. ,2001. *Group life*, eds L. J. Keeling and H. W. Gonyou (Social behaviour in farm animals.: CABI Publishing) 37-58.

Mačuhová, Juliana, Tančin, Vladimír, and Bruckmaier, Rupert M. , 2003. Oxytocin release, milk ejection and milk removal in a multi-box automatic milking system. *Livestock Production Science,* 81 (2–3), 139-47.

Melin, M., Wiktorsson, H., and Norell, L., 2005. Analysis of Feeding and Drinking Patterns of Dairy Cows in Two Cow Traffic Situations in Automatic Milking Systems. *Journal of Dairy Science,* 88 (1), 71-85.

Melin, M., 2006. Cow traffic in relation to social rank and motivation of cows in an automatic milking system with control gates and an open waiting area. *Applied Animal Behaviour Science,* 96 (3–4), 201-14.

Melin, Marlin, 2007. The effects of restricted feed access and social rank on feeding behavior, ruminating and intake for cows managed in automated milking systems. *Applied Animal Behaviour Science,* 107 (1–2), 13-21.

Mepham, T. B. and Forbes, J. M., 1995.Ethical aspects of the use of immunomodulation in farm animals. *Livestock Production Science,* 42 (2–3), 265-72.

Munksgaard, L., 2011. Forced versus free traffic in an automated milking system. *Livestock Science,* 138 (1–3), 244-50.

Olofsson, J. , 1999. Competition for total mixed diets fed for ad libitum intake using one or four cows per feeding station. *Journal of Dairy Science,* 82 (1), 69-79.

Peeler, E. J., 2000. Risk Factors Associated with Clinical Mastitis in Low Somatic Cell Count British Dairy Herds. *Journal of Dairy Science,* 83 (11), 2464-72.

Phillips, C. J. C. and Rind, M. I. , 2002. The Effects of Social Dominance on the Production and Behavior of Grazing Dairy Cows Offered Forage Supplements. *Journal of Dairy Science,* 85 (1), 51-59.

Prescott, N. B., Mottram, T. T., and Webster, A. J. F., 1998. Relative motivations of dairy cows to be milked or fed in a Y-maze and an automatic milking system. *Applied Animal Behaviour Science,* 57 (1–2), 23-33.

Rousing, T., 2006. The association between fetching for milking and dairy cows' behaviour at milking, and avoidance of human approach — An on-farm study in herds with automatic milking systems. *Livestock Science,* 101 (1–3), 219-27.

Rushen, J., 2001. Human contact and the effects of acute stress on cows at milking. *Applied Animal Behaviour Science,* 73 (1), 1-14.

Sambraus, H. H. , 1977. Observations and experiments on social behaviour in a herd of cattle during an 11-year period. *Applied Animal Ethology,* 3 (2), 199-200.

Syme, G. J. , 1974. Competitive orders as measures of social dominance. *Animal Behaviour,* 22, Part 4 (0), 931-40.

Wierenga, H. K. and Hopster, H. ,1990. The significance of cubicles for the behaviour of dairy cows. ***Applied Animal Behaviour Science,*** **26 (4). 309-37.**

I denna serie publiceras examensarbeten (motsvarande 15, 30, 45 eller 60 högskolepoäng) vid Institutionen för husdjurens utfodring och vård, Sveriges lantbruksuniversitet. Institutionens examensarbeten finns publicerade på SLUs hemsida *www.slu.se*.

In this series Degree projects (corresponding 15, 30, 45 or 60 credits) at the Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, are published. The department's degree projects are published on the SLU website *www.slu.se*.

Sveriges lantbruksuniversitet Fakulteten för veterinärmedicin och husdjursvetenskap Institutionen för husdjurens utfodring och vård Box 7024 750 07 Uppsala Tel. 018/67 10 00 Hemsida: www.slu.se/husdjur-utfodring-vard	*Swedish University of Agricultural Sciences* *Faculty of Veterinary Medicine and Animal Science* *Department of Animal Nutrition and Management* *PO Box 7024* *SE-750 07 Uppsala* *Phone +46 (0) 18 67 10 00* *Homepage: www.slu.se/animal-nutrition-management*